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Isotopic and physiological responses during short-term acclimation to atmospheric CO2 concentration in Pinus nigra.

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The response of plants to increasing atmospheric CO2 concentrations will have an important influence on biogeochemical cycles in the future. These responses are physiologically driven, but have important feedbacks to water and nutrient cycles as the plants adjust photosynthetic activity within the constraints of these other cycles. Leaf scale manipulations of CO2 concentration provide us with a wealth of information on the short-term, biochemical response of leaf photosynthesis, but these responses do not translate to whole plant responses under sustained growth at higher CO2 concentrations, as has been evidenced by free air enrichment studies. Here we report on a study into whole plant responses to CO2 concentration using a new, 10m3 isotope-biogeochemistry growth chamber housing small (1.5m) potted Pinus nigra trees under controlled conditions. This chamber is capable of controlling the climatic and CO2 conditions and designed for sampling biogeochemical pools for isotopic analysis with minimal disturbance to the system. The trees were maintained at 20°C and 50-60% RH, and at three CO2 concentrations (380 ppm, 500 ppm, 800 ppm) for ∼10 days each to explore whole-plant physiological acclimation responses with other factors being constant (i.e. soil nutrient and water status). New steady-state conditions were reached after 5-6 days, and samples of chamber air and transpired water vapour were collected during a diurnal period at the end of the treatment period and analysed for their isotopic (13C, 18O) composition. Transpiration rate and 18O composition were relatively steady over the photoperiod, while the 18O of air CO2 typically displayed a 5-10 permil decline. The 13C of air CO2 varied by 2-3 permil over the day, but did not show a consistent pattern between treatments. There was a highly correlated enrichment in the end-of-day values of atmospheric CO2 18O (by ∼3 permil) and 13C (by ∼2 permil) across the three CO2 concentrations. Transpiration trends were consistent between leaf-level and total canopy measurement, and leaf-level gas exchange measurements indicated that there was a 125% increase in water use efficiency between 380 ppm and 800 ppm, driven by both reductions in stomatal conductance (33%) and increases in CO2 assimilation rate (39%). Ongoing measurements include the analysis of leaf, twig and soil water and leaf sugars.